



DECLARATION OF RICHARD SHIFLER

pmu

15
12/19/00

RICHARD SHIFLER, having personal knowledge of the facts set forth herein except where such facts are stated to be on information and belief states that

1. I have been retained by Demag Delaval Turbomachinery Corporation ("Demag"), the assignee of the above application, to review the Office Action of June 5, 2000, the art cited in that action as well as the claims now pending in Application No. 09/199,127 (the Addis patent application).

2. I received a Bachelor of Mechanical Engineering degree from John's Hopkins University in 1947.

3. Since receiving my degree I have been employed for almost fifty years in various engineering, management and consulting capacities involving steam turbines.

4. During the period from 1947 to 1968, I was employed by General Electric Company ("GE"). During the period of my employment by GE, I was involved in the design and development of steam turbines holding a number of engineering positions including product design engineer, development engineer, design engineer and test engineer.

5. In 1968 I left the employ of GE and became employed by Imo Delaval Incorporated from 1968 to 1987. On information and belief, Imo Delaval Incorporated is a predecessor of Demag Delaval Turbomachinery Corporation, the assignee of the Addis patent application, but I do not know the details of the legal relationship of these companies. While at Imo Delaval, I held managerial positions involving the design and development of steam turbines including Manager of Product Engineering, Manager of Turbine Engineering and Assistant Chief Engineer, turbines.

6. After retiring from Imo Delaval in 1987, I was a founder of, and the President of RMX Incorporated from 1988 to 1996. In addition to holding the office of President I also acted as a consulting engineer with RMX. RMX was in the business of

providing consulting services to companies in the turbine industry. Since 1996, I have been self-employed as a consulting engineer on matters relating to turbomachinery including steam turbines.

7. I consider myself a person skilled with respect to turbine machinery and shaft seals for use in such machinery, the art to which the Addis application relates. I have worked with engineers in this field for many years; i.e., persons of ordinary skill in the art, and the opinions I express herein would, in my opinion, typify the views of the engineer having ordinary skill in this art.

8. In this declaration I will discuss the technical differences between the claimed invention and prior art on which the Examiner has relied and explain the benefits of the claimed invention.

9. The Addis invention, as most broadly claimed in the independent claims now pending, is a retractable shaft seal for use in a turbine in which the sealing member includes a brush seal element.

10. I have read the Examiner's action of June 5, 2000 and understand that these claims of the Addis application have been rejected as obvious and unpatentable over United States Patent No. 5,810,365 to Brandon ("the Brandon '365 Patent") in view of United Kingdom Patent GB 2,301,635 to Hemsley ("the Hemsley Patent") and United States Patent No. 5,316,318 to Veau. ("the Veau Patent").

11. The concept of a retractable shaft seal in which the seal is opened by springs at low loads and closed by the working fluid of the turbine at operating loads has been known since the United States Patent No. 4,436,311 which issued to Ronald Brandon in 1984. Variations of this retractable seal construction are disclosed in the Brandon '365 Patent which was relied upon by the examiner in his rejection.

12. In a retractable seal, as illustrated by both of the Brandon patents, the seal is movable so that there is a large clearance between the seal and the shaft at

start up and at low turbine loads when the turbine shaft tends to be unstable and a small clearance between the seal and the shaft at normal turbine operating loads.

13. When the turbine is shut down, starting up or operating under low loads, springs biased against the seal segments move them radially outwardly until this outward radial motion is stopped by a stationary turbine surface such as the inside of the casing shoulders or the bottom of the casing groove. In this open position, there is a large clearance (normally about 125 mils.) between the shaft and the ends of the labyrinth teeth of the sealing member. This clearance is large enough so that the turbine shaft will not contact and damage the seal teeth during periods when the turbine shaft tends to become unstable.

14. Steam pressure increases as load increases in a steam turbine. When a desired turbine load has been reached, pressure exerted by steam which flows into the casing groove becomes high enough to force the seal segments radially inwardly until they are stopped by a stationary turbine surface such as the upper casing shoulders. In this closed position, there is a small clearance between the ends of the seal teeth and the shaft (normally about 25 mils) which permits efficient operation of the seal. To be effective a retractable seal must close automatically and reliably when the desired turbine load is reached.

15. In both of the Brandon patents the sealing member of the seal segments is a number of teeth projecting radially toward the shaft. These teeth cooperate with raised areas (lands) on the rotating shaft to form a labyrinth seal. (See Brandon '365, Figures 3, 4 and 5).

16. Prior to the filing of the Addis application I am not aware of any prior art device or publication that disclosed or incorporated a brush seal element as a part of the seal member of a retractable seal.

17. The British Hemsley Patent shows the use of a brush element in a shaft seal but the structure disclosed in Hemsley is not a retractable seal.

18. The Hemsley patent discloses a conventional shaft seal in which the springs 23 bias the seal segments toward the shaft so that they are always at their small clearance position with respect to the shaft. In the retractable seals of the Brandon patents, the springs act in the opposite direction to bias the seal segments away from the shaft so they are at their large clearance position with respect to the shaft during shutdown, startup and low loads.

19. As seen in Hemsley Figure 1, the spring 23 biases the seal segment (body member 13) radially inwardly toward the shaft 12 at all times. If the shaft contacts one of the seal segments, the segment is forced radially outwardly against the bias force of the spring 23 but the spring tends to return the segment to its small clearance position adjacent to the shaft. This is what the Hemsley patent is referring to when it states that the seal segment (body member) "floats". (Hemsley Pg. 3 Lns. 14-17). This arrangement will not prevent seal damage during periods of shaft instability since the segment only moves outwardly after it has been contacted and potentially damaged by the shaft.

20. In Hemsley, the brush seal element includes a brush 34 mounted in a carrier 29 which is fitted into a recess 27 formed in the body of the seal segment 13. so that it replaces one of the fins of the labyrinth seal. Lugs on the carrier 29 fit into slots 31 in the side walls 32 of the recess 27 with some clearance.

21. The Hemsley patent states that this clearance between the carrier 29 and the recess 27 allows a small amount of radial movement of the assembly 28. Since the Hemsley spring 23 biases the seal segment toward the shaft, the brush element and the other elements of the labyrinth seal are always held at their small operating clearance and the small clearance between the carrier and the recess will not protect

the seal elements from damage when the shaft contacts the seal segment during unstable shaft behavior at startup and low loads.

22. The Hemsley structure is arranged so that the brush seal element rubs against the shaft. While this contact is desirable to provide the best possible steam seal, it will insure that the brush element rubs against the shaft at start up and under low loads when the shaft is unstable. This rubbing during unstable shaft operation causes excessive wear and can cause heating of a portion of the shaft surface which will cause the hotter portion of the shaft to bow outwardly due to thermal expansion. As the shaft rotates, this bowed portion can damage the seal and the turbine shaft causing a serious problem.

23. To prevent this the retractable brush seal, as shown and claimed in the Addis application, moves the brush element away from the shaft during the period of shaft instability and greatly decreases or eliminates the problem of seal wear or damage and the problem of shaft bowing. It then returns the brush to its position in contact with the shaft under normal operating conditions to provide an efficient seal.

24. While there are advantages to using a brush element as a part of the seal member of a retractable seal, it was not obvious prior to the Addis application that such a combination would work because of the complex interaction of the forces necessary to open and close a retractable seal.

25. Including a brush seal element as part of the labyrinth seal in the Hemsley Patent does not change the way the seal operates because the Hemsley seal does not move between a small and large clearance position. The spring 23 keeps it at the small clearance operating position at all times.

26. Unlike the conventional seal of Hemsley, a retractable seal must move radially and is subjected to a complex interaction of forces that determines whether the seal is open or closed. These forces are (1) the steam pressure in the casing groove

which closes the seal, (2) the bias springs that open the seal, (3) the frictional forces between the casing and the seal segment which oppose movement, (4) the weight forces of the seal segments and (5) the steam forces on the segments tending to open the seal.

27. The only force available to close a retractable seal is the force exerted by the steam pressure in the casing groove. This force increases with turbine load and must be high enough, when the turbine reaches the desired load, to overcome the combination of the forces tending to keep the seal open. The forces tending to keep the seal open include the spring bias force, the frictional forces and some of the steam pressure forces on the segment.

28. As steam moves through the labyrinth from the high pressure to the low pressure side of the seal, the pressure drops as steam passes each of the labyrinth teeth and any brush elements which form the seal. Because of these pressure drops, the steam pressure on the inner radial side of the seal becomes less than the steam pressure force in the casing groove as load increases. This steam pressure force difference is used to "automatically" close a retractable seal when the turbine reaches a desired load.

29. However, not all steam pressure forces act to close the seal. While the steam pressure drops over seal elements at the high pressure end of the seal generate a resulting pressure force tending to close the seal, pressure drops at the lower pressure end generate forces tending to keep the seal open.

30. The amount of pressure drop that occurs over each element of the seal depends on the clearance between the element and the shaft. The ends of the labyrinth teeth are spaced a greater radial distance from the shaft than the brush seal element. As a result, a much greater pressure drop will occur across the brush element

than across the labyrinth teeth and the axial positioning of the brush element is very important and can determine whether or not there is enough force to close the seal.

31. In addition, since the brush element is in contact with the shaft, it will wear away during use. As the brush wears away, its clearance with respect to the shaft increases and the pressure drop across this seal element decreases causing a relatively greater portion of the pressure drop to occur across the labyrinth teeth. This changes the force distribution on the seal segments and can either prevent the seal from closing or can cause it to close at a higher or lower turbine load than is desirable.

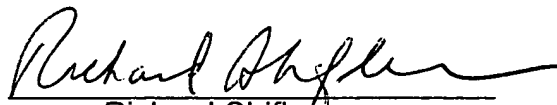
32. Although one can just add a brush element to a conventional seal, such as Hemsley, and expect it to work, this cannot easily be done with a retractable seal. If the retractable seal is to operate properly, the optimum axial position of the brush element and other geometry must be determined to accommodate all expected operating conditions.

33. The Veau reference only discloses a brush seal element which is not a part of a retractable seal. The use of brush seal alone or a conventional seal alone were known in the prior art, but as discussed above the combination of a brush element with a retractable seal was not.

34. In my opinion, for all of the above described reasons, the Addis invention would not be obvious in view of the teachings of the Brandon patents alone or combined with the teachings of either of the Hemsley or Veau references.

35. I declare under penalty of perjury that the foregoing is true and correct.

Executed on 12-4-2000


Richard Shifley